HYDRO-GEOCHEMICAL CHARACTERISTICS OF SURFACE AND SUB-SURFACE WATER OF LALMATIA COAL MINE AREA OF RAJMAHAL BASIN OF GODDA DISTRICT JHARKHAND, INDIA

A Synopsis submitted to University Department of Geology,
Ranchi University, Ranchi, Jharkhand for Ph.D. Registration.

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The topic of the research :

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1. A BRIEF INTRODUCTION OF THE RESEARCH TOPIC

Water is an extremely valuable natural resource that is used extensively for home, commercial, industrial, and agricultural purposes worldwide and that enters the environment through a variety of sources [1,2,3].

Many nations throughout the world depend heavily on coal mining for their economic success [4,5,6]. India currently ranks third in the world for coal production, with over 319 billion tonnes of coal reserves [7,8].
The most identifiable and observable environmental issue is caused by coal mining, whether it be through open-cut or underground mining. This is because the mining process changes the physical, chemical, and biological parameters of the surrounding environment and has a significant impact on both the ecological unit and human civilization [1,9,3]. The quantity and quality of water are equally significant [10,11].
The quantity and quality of surface water and groundwater in mining sites can be negatively impacted by mining [12,13], endangering the water resources' sustainability [14] and the local population's general health [15,16]. Reports of mining waste discharges causing ecological deterioration and health issues have been made globally [17,18,19], drawing interest from academics and decision-makers alike [20].

However, the issue of poor water quality is especially acute in regions with a high concentration of the mining and mineral processing sectors. Particularly during mining operations, a number of waste classes are created, which have the potential to produce different kinds of pollution before contamination happens [1,21,3]. Therefore, assessing the ground water in mining sites is crucial [3].

Understanding the hydro-chemical and geochemical properties of surface and ground water is crucial for determining their appropriateness for various uses [3]. Understanding the mechanism and processes involved in the removal of overburden, resource exploitation, production of coal mine waste and mine drainage, and offsetting the balance in the local and regional aquatic system depends on groundwater quality studies as well as hydrogeochemical research in coal mining areas. Essential information regarding groundwater replenishment, migration, circulation, and discharge sources can be obtained from hydrochemical properties [22,8].

2. STATE OF THE ART

Natural processes like rock-water interaction and seawater intrusion have an impact on groundwater quality[23], in addition to manmade inputs like those from mining activities [24]. The hydrogeological context of active coal mining areas, combined with large overburden (OB) material dumps, presents a challenging set of obstacles for quantifying and comprehending the mechanisms that regulate water quality. These human-caused interventions can occasionally start processes and interactions that seriously harm groundwater resources [25]. When coal is extracted from open-pit mines, waste or OB materials are created. Some of these materials are

discarded inside the mine as internal dumps, and others are piled onto the surface next to the mines as external dumps. Water that has precipitated penetrates through these OB materials and into the nearby groundwater aquifer through active strip mines. After being used for mining operations, excess water from mines is either released onto the surface for irrigation or used for residential use [26]. Therefore, unless safety precautions are taken, there could be dangerous outcomes. Furthermore, the water table is significantly lowered as a result of mine dewatering, which is necessary for all opencast and underground activities [27,28]. This drop in the water table also causes groundwater from nearby places that may include pollutants and dissolved materials to flow into the earth, which has an impact on the groundwater's quality. As a result, having accurate information about water quality is essential since it affects how well water resources are managed and used [29,30,31].

2.1 LOCATION OF THE STUDY AREA

Lalmatia coal mine is located in godda district which comes under the Boarijor CD block in godda subdivision in the Indian state of Jharkhand. The block is located between latitudes $25^0$1’12” N and $25^0$3’15” N and Longitude $87^0$21’0” E and $87^0$24’0” E and occupies an area of around 15 sq. km. The surrounding villages are Lalmatia, Dakaita, Hijukita, Basdiha, Lohandia, Bhorai, Bara Simra, Neema, Kendua, Telgama, Kusuma, Tetaria, Ballia etc.

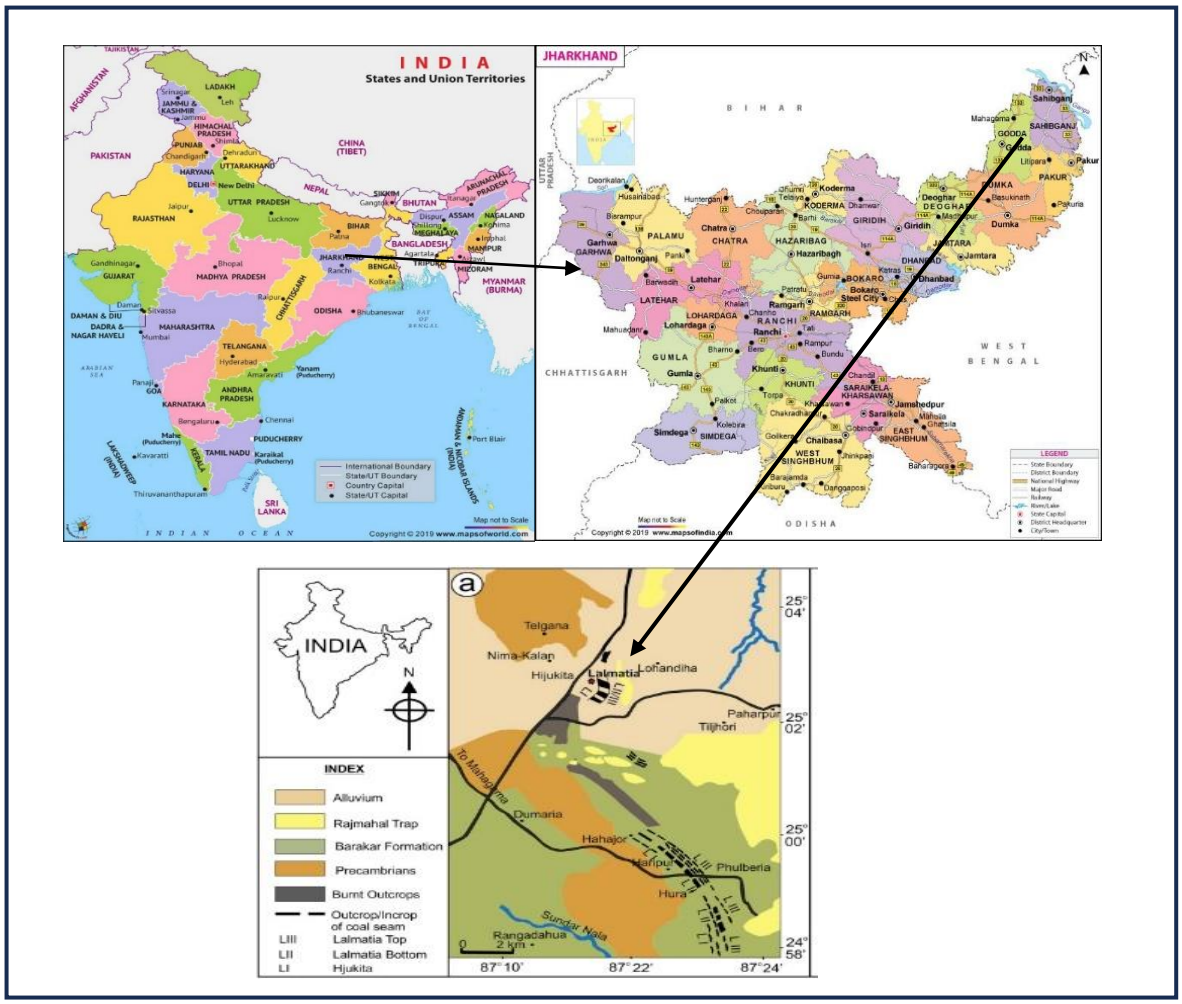


Fig 1: Location map of the study area

The study area falls in the Survey of India Toposheet no. G45P8 (OSM no.) and 72O/8 (sheet no.) (scale 1:50,000).

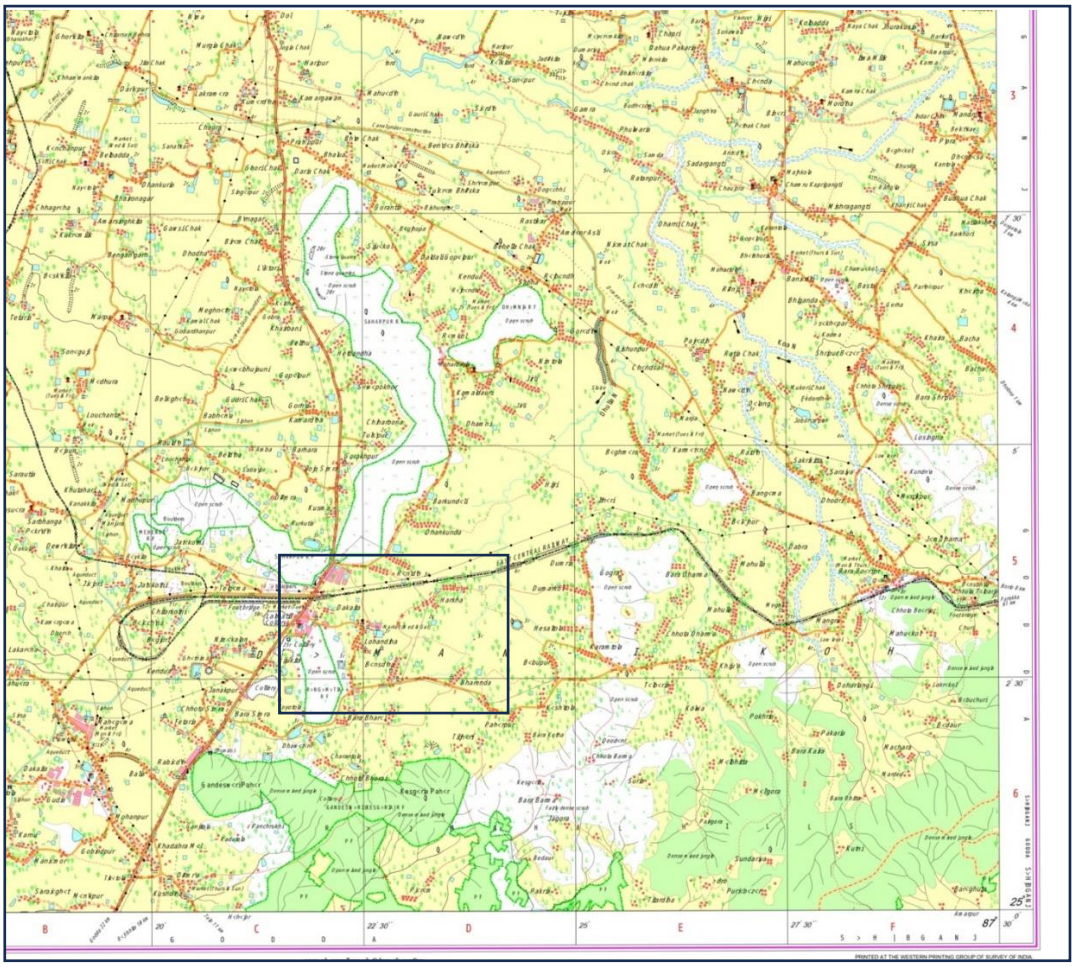


Fig 2 : Toposheet map of the study area (Lalmatia, district- Godda)

OSM no.-G45P8, Sheet no.- 72O/8 (Scale 1:50,000)

2.2 GEOLOGY AND STRATIGRAPHIC SEQUENCE

The Rajmahal Basin is thought to have developed from tholeiitic magmatism during the Gondwana period. The Barakar and Talchir formations are situated beneath the undifferentiated Triassic layers beneath the trap [32]. In the foot of the Rajmahal hills, the lower Gondwana exposures comprise the Rajmahal coal fields, which are generally aligned in a north-south direction. There is a depositional contact between the Barakar Formation and the Archeans that is located toward the west. Parts of the coalfield have also been found to expose the lithostratigraphic units Dubrajpur, which underlies the Rajmahal traps, and Talchir, which underlies the Barakar formation.The general geological succession exposed in the Rajmahal area, eastern Jharkhand is given in Table 1 [33,34].

The Lalmatia exploration block, including 15 square kilometers, is home to the Rajmahal open cast mine and has been explored by the Central Mine Planning and Design Institute (CMPDI) [35].

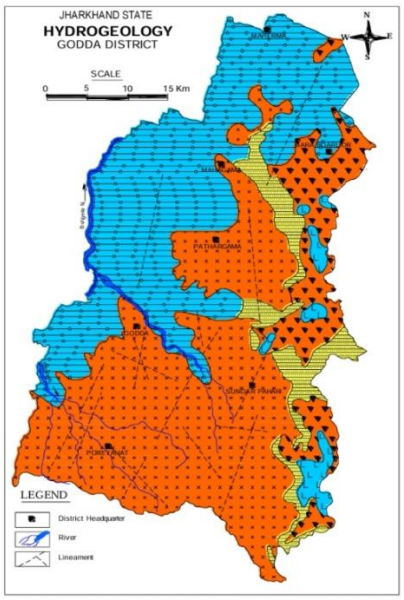
Table 1: Geological succession exposed at the Rajmahal area, eastern Jharkhand (after Raja Rao, 1987[33]; Singh and Singh, 1996[34]).

Age	Formation	Lithology	Thickness
Recent to sub-recent	Alluvium	Loose soil, silt and clay	Upto 80 m
----------UNCONFORMITY----------			
Early Cretaceous to Early Jurassic	Raajmahal Traps and Inter-trappeans	Flows of basalt, pitchstone and Inter-trappean beds (sandstone, shale and ash)	600 m
----------UNCONFORMITY----------			
Late Triassic	Dubrajpur	Pebbly sandstone, Coarse to medium grained sandstone, red siltstone	60-250 m
----------UNCONFORMITY----------			
Early Permian	Barakar	Coarse to medium grained sandstone, pebbly sandstone, gray shales, clay and coal seams	250-550 m
	Karharbari	Grits, conglomerates and carbonaceous sandstones	
	Talchir	Tillite, fine to medium grained sandstones, olive green shale	
----------UNCONFORMITY----------			
Archean		Basic rocks, amphibolites, bands of quartzite, limestone, gneisses and granite	

2.3 HYDROGEOLOGY

Godda district enjoys a cold winter, a good monsoon, and an oppressively hot and dry summer. The year can be divided into four seasons. Summer extends from March through the first week of June, and winter spans from December to February. The months of the southwest monsoon are June through September. The post-monsoon season, which spans from October to November, occurs between the monsoon and winter seasons. The highest rainfall occurs in July [36].

In all of the lithological units that make up the shallow aquifers, ground water is primarily found in a phreatic state. In deeper aquifers, it is occasionally found in semiconfined and confined conditions [37].



LEGEND

AGE GROUP	LITHOLOGY	SYMBOL	HYDROGEOLOGICAL CONDITION	GROUND WATER POTENTIAL
			UNCONSOLIDATED / POROUS FORMATION	
Quaternary	Recent & older alluvium clay, sand, gravel, calcareous & ferruginous concretion		Moderatelly thick, regionally extensive unconfined / semi confined aquifer down to 100m.	Good yield prospect 25 - 75 m ³ / hr.
Tertiary	Laterite		Thin veneer in patches under unconfined aquifer down to 10 - 15 m.	Limited yield prospect 5 m ³ / hr.
			SEMICONSOLIDATED FORMATION	
Gondwana super group	Sandstone, shale, siltstone, with coal seams.		Moderatelly thick, regionally extensive confined qquifer / free flowing condition down to 200m.	Very good yield prospect 50 - 100 m³ / hr.
			CONSOLIDATED FORMATION / FISSURED FORMATION	
Rajmahal Trap	Basalt with intertrappean sandstones & shales		Groundwater restricted to weathered zone, fractured zone. Contact of two flows & intertrappeans down to 100m.	Limited yield prospect blow 25 m ³ / hr at selective places.
Precambbrian	Granite - gneiss, mica schist amphibolotes etc.		Groundwater restricted to weathered zone, fractured zone. down to 150m.	Moderately good yield prospect 10 - 40 m ³ / hr at selective places.

Fig 3 : Hydrogeology of the godda district [37].

2.4 DRAINAGE

The district's main rivers are the Harna, Sunder, Sapin, Kao, Cheer, and Geura. The drainage generally flows in a SE-NW direction. The structural elements, in particular the joints and foliation, have a significant influence on drainage and regulate the district's drainage pattern [37].

2.5 LITERATURE REVIEW

Ball (1877) studied the structure and stratigraphy of Rajmahal Basin [38]. Exploration was done in this area by numerous workers (Madabhushi and Mukherjee, 1980[39]; Roy et al., 1983[40]; Das et al., 1985[41]; Madabhushi, 1985[42a], 1990[42b]; Singh, 1992[43]). The Coal seams are underlain by the Barakar Formation is reported by Raja Rao (1987)[33]. Few reports exist on the organic petrography and geochemical characterization of coal by Singh (1992)[43] and Singh and Singh (1996)[34]. Due to the abundance of plant megafossils and palynomorphs, the intertrappean beds of Rajmahal have been thoroughly investigated (Sahni, 1932[44a], 1948[44b]; Sahni and Rao, 1933[45]; Rao, 1943[46]; Vishnu-Mittre,1956[47a], 1958[47b]; Sharma, 1967[48a], 1969[48b], 1974[48c], 1997[48d]; Sengupta, 1988[49]; Banerjee, 1993[50a], 1995[50b], 2000[50c]; Banerji and Jana, 1998[51]; Tiwari et al., 1984[52]; Baksi et al., 1992[53]; Tiwari and Tripathi, 1995[54]; Tripathi, 2008[55])[35]. On the coal-bearing sequences in the Rajmahal Basin, numerous investigations have been conducted particularly on the morpho-taxonomical (Feistmantel, 1880[56]; Singh et al., 1987[39]; Bajpai and Maheshwari, 1991[57]; Maheshwari and Bajpai, 1992[58]; Srivastava and Pant, 2002[69]), palynology (Tripathi and Ray, 2005[60]; Tripathi et al., 2010[61]), petrological (Roy et al., 1983[40]; Madabhushi, 1990[42b]; Singh, 1992[43]), molecular composition and hydro-carbon potential (Tiwari et al., 2016[62a], 2017[62b]) aspects [32].

Work on ground water resources have been assessed by Remote sensing technology (Saraf & Choudhary (1998)[63]; Asadi et al. (2007)[64]; Singh (2007)[65]; Latha (2010)[66]; Singh and Khan (2011)[67]; Ilayaraja and Ambika (2015)[68]; Oseke et al. (2021)[69]. The work on A correlational study of uranium in groundwater with other physicochemical parameters using GIS mapping

in Godda district of Jharkhand, India was done by Srivastava et. al., (2023) [36]. Other work is on Geochemical mobilization of Arsenic, Chromium and Uranium in Gangetic Plain of Bihar and Jharkhand done by Jha et. al., (2023)[70].

3. PROBLEMS TO BE INVESTIGATED

- To estimate the quality of ground water and surface water.
- To estimate the water quality index (WQI).
- To examine the groundwater parameters.
- Characterization of hydro-geochemical facies variations.
- Assessment of various factors that control the quality of groundwater, river water and their suitability for various utilization.
- Investigation of the effect of active coal mining on groundwater resources of the study area.
- Its impact on public health and the extent to which water can be used in various ways based on its quality.

4. OBJECTIVES OF THE INVESTIGATION AND MOTIVATION

- To understand the water quality and ecology of the area affected by coal mining.
- To understand the effect of mining on the natural resources utilised.
- To make a database of groundwater chemistry in the coal mining areas, which will be useful in future assessment for the impact of coal mining operations in the study area.

Motivation : In coal mining locations, common issues include the deterioration of water quality, the production of acidic mine drainage water, the discharge of heavy metals, and mixing with nearby aquifers and water supplies. All of these factors have a major negative influence on groundwater resources. In order to maintain drinking water standards for both the present and the future, it is imperative that water quality indicators be regularly monitored and assessed [8].

5. RESEARCH HYPOTHESIS

The hydrogeochemical characteristics of the groundwater provide a critical framework for assessing the quality of groundwater and the aquifer's solute acquisition process.The number of hydrogeochemical processes that result in a change in the fluid medium's chemical composition and do not conflict with one another control the flow of groundwater throughout its course from recharge to discharge locations. Therefore, understanding the hydrogeological system and the processes involved in the hydrogeochemical evolution is essential to designing a sustainable ecosystem[71,72]. In order to evaluate surface and groundwater sources of drinking water, a thorough impact assessment of the principal ions in the physicochemical parameters must be conducted. As a result, an indexing technique called the water quality index (WQI) offers a cumulative evaluation of drinking water quality criteria [8].

6. RESEARCH DESIGN AND METHODOLOGY

The research design and methodology will encompass:

Step 1:

- Literature survey
- Field survey
- Sample collection pre monsoon and post monsoon
- Photography
- Classification
- Make arrangement for storage of the sample

Step 2 : Research analysis will be carried out in the following stages:

- Chemical analysis
- Evaluation of water quality index (WQI)
- Health risk assessment
- Interpretation and correlation

❖ **Collection of samples:**

- The samples of groundwater will be collected from dug wells, bore wells and hand pump and the surface water samples from ponds, rivers and mine effluent water in the study area.
- All samples will be collected in a 1-litre capacity polyethylene bottles. Before sampling, the bottles will be washed with respective samples to avoid being contaminated.
- After tapping the water, in situ parameters such as hydrogen ion concentration (pH), temperature (T), total dissolved solids (TDS), and electrical conductivity (EC) will be determined at the sampling sites itself with the help of a Ph meter and a portable multi-parameter tool kit.

❖ **Chemical analysis**: The physicochemical analysis of water samples will be carried out as per the procedure using standard procedure suggested either by Indian standard (IS) or American Public Health Association (APHA 2017).

❖ **Evaluation of Water Quality Index (WQI) :**

- WQI of water sample will be calculated by combining the values of several parameters to produce a single figure that represents the water's quality or level of pollution [73].
- Different weights will be assigned for physicochemical parameters .

❖ **Interpretation and correlation** : The interpretation and correlation will be made on the basis of results obtained by above analysis.

7. SOURCES OF DATA AND TOOLS TO BE USED IN COLLECTION OF DATA

- Clinometer compass
- Handheld GPS
- Toposheet
- Markers
- 1 litre capacity Polyethylene bottles
- Notepad and Pen
- Camera
- pH meter
- a portable multi-parameter tool kit

8. SIGNIFICANCE OF THE STUDY

- The groundwater chemistry study will be useful to study the impact of coal mining on the water resources of the area.
- The calculation of the water quality index (WQI) determines whether the quality of water is fit for drinking purposes.
- Health risk assessment is a crucial prerequisite for studies relating to groundwater quality appraisal. It is a set of techniques that are aimed at evaluating the potentially harmful impact of groundwater on human health [74,75,76,77,78,79,8].

9. ITS RALEVANCE TO THE PRESENT DAY PROBLEM AND NEED TO THE SOCIETY

Water quality and chemistry are impacted by coal mining operations both during the active mine life and even decades after the mine closes [80,81,8]. One of the main things that can lower the rates of baby and mother mortality is clean drinking water. Long-term exposure to pollutants is harmful to people's health and well-being. High levels of pollution in water are extremely dangerous for human health and endanger the entire environment that supports life.

10. CONTRIBUTION TO THE EXISTING KNOWLEDGE

Policymakers and water management boards will benefit from the research's findings in terms of access to clean drinking water. The understanding of the hydrological milieu and the mechanisms influencing the groundwater chemistry in the coal mining sites may be greatly enhanced by this investigation. For the purpose of monitoring, long-term protection, effective management of water resources, and preventing health concerns associated with coal mining operations in the area, a baseline database on water chemistry will be generated.

11. FUTURE WORK

- The current study's findings will support the efforts of health authorities to conduct additional epidemiological investigations and gather comprehensive data regarding human exposure to ions found in surface and ground water.
- Managing the precious water resource and meeting future water demands in the coalfield area will be made much easier with the baseline data on water analysis.
- The resulting data will be helpful to the NGO's (national or international) working for water quality and its impact on living beings.
- On the basis of obtained data, a detailed elemental research work can be initiated for that particular area and also for other mining areas.
- This paper will be helpful to the researchers for their study in that area in future.
- This study of the water analysis can be helpful for the students and research scholars of geology, geography and environmental science.

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